

Research on Water Quality Monitoring and Evaluation System under Agricultural Irrigation Automation

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Abstract. In order to timely grasp the status and change trend of the irrigated agricultural water environment, we refer to the farmland irrigation water quality evaluation standards, and select 11 monitoring items in different basins to monitor the agricultural irrigation water quality for 2 consecutive years. The article uses the pollution index method to evaluate the monitoring results. The results show that the comprehensive pollution index of surface irrigation water and underground irrigation water quality is less than 1, but there is a rising trend; the concentration of some pollutants in the irrigation return water is higher than that of the irrigation water, and some individual indicators exceed the standard, but they do not constitute comprehensive pollution. Finally, through the design of the remote sensing image water quality monitoring and evaluation system (RWQMES), the unified management of the three functions of water quality remote sensing image analysis and processing, water quality prediction and evaluation is realized.

Key words. Agricultural irrigation automation, water quality monitoring, water quality evaluation system.

1. Introduction

A good water environment is an important condition for the healthy development of agricultural production. Agricultural non-point source pollution caused by the extensive use of chemical fertilizers, pesticides, and animal manure for many years in agricultural production has become increasingly prominent, leading to further shortages of functional water in rural areas and threats to the quality and safety of agricultural products [1]. The technical countermeasures to control agricultural non-point source pollution are mainly to control the entry of pollutants into water bodies from the source. According to the surface water environmental quality standards promulgated by the state, the V-type water suitable for agricultural water areas requires total nitrogen $\leq 2.0\text{mg/L}$ and total phosphorus $\leq 0.4\text{mg/L}$. The continuous flow analyser is especially suitable for the analysis of large quantities of water environment samples because of its advantages such as fast analysis speed, simple operation, good reproducibility, and low consumption. The method not only has high accuracy and precision in agricultural water quality monitoring, but also is fast and reliable, and can meet the needs of large quantities of samples.

The automatic water quality monitoring can automatically and continuously monitor the water quality, and the data can be automatically transmitted remotely, and the water quality data of the set site



can be inquired at any time. The development of automatic water quality monitoring can solve the current problems of long water quality monitoring cycle, high labour intensity, slow data collection and transmission speed, and change the passive situation of providing water quality information to relevant departments after the fact [2]. When it deteriorates, the instrument automatically alarms or responds, and sends out early warning and forecast of water pollution in the basin and downstream, preventing problems before they occur, and has major social and economic benefits.

2. Importance of harmless treatment of agricultural sewage

2.1. Water pollution makes agricultural water use worse

China's existing water resources can no longer meet the needs of agricultural water. Pollution of water resources has made water supply worse, and water supply conflicts have intensified. At present, the national sewage discharge reaches tens of billions of tons every year. 80% of the sewage is directly discharged into rivers and lakes without treatment, causing most of the rivers and lakes to be polluted to varying degrees. With the rapid rise of township and village enterprises, water pollution has spread from cities to the vast suburbs and rural areas. Severe water pollution endangers agricultural water. Farmers use it for farmland irrigation regardless of whether the water quality meets the water quality standards for farmland irrigation [3]. Especially for those arid or semi-arid northern water-deficient areas or periods of prolonged drought and water shortage, the lack of agricultural water has to be supplemented by industrial wastewater and domestic sewage. Sewage has become a part of the water source for agricultural production. Based on this situation, many scholars believe that due to the complex composition of many sewage water, the large number of pollutants in the water and the high concentration, especially when the types of harmful and toxic substances in the water are increasing, the sewage that has not been harmlessly treated is directly used. Irrigation and breeding of farmland will inevitably bring many hidden dangers and cause great harm. Strengthening sewage treatment, strict control of agricultural water quality standards and scientific guidance are effective ways to solve China's current agricultural sewage irrigation. Sewage is a kind of water resource that can be used for irrigation, and it is also the culprit of environmental pollution. It is of great significance to make sewage harmless and make it recyclable.

2.2. Harmfulness of sewage irrigation

During the "Eighth Five-Year Plan" period, China's annual average sewage discharge was 39.97 billion m³. With the rapid development of China's industry and township enterprises, sewage discharge will increase greatly in the future, and it will exceed 50 billion m³ in the near future. Although sewage irrigation temporarily solves the problem of agricultural water use, and some even increase soil fertility and crop yields, in the long run, crops will be polluted to varying degrees and cause a vicious circle [4]. The presence of toxic and harmful substances in the sewage and severely exceed the standard, so that the soil is alkalized, acidified, salinized and compacted, and the soil structure is destroyed. The most serious of these is heavy metal pollution, especially mercury, cadmium, and lead pollution. The most direct harm of land pollution is that it is not conducive to the growth of plants, leading to reduced crops or even no harvest. Harmful and toxic substances in the soil are absorbed and accumulated by crops, enter the human body through the food chain, and accumulate in the human body and endanger human health. There are many reasons for land pollution, but the main reason is the pollution of agricultural products caused by industrial wastewater and domestic sewage irrigation. At present, the treatment of land pollution, especially heavy metal pollution and nuclear radiation pollution in the land, is a worldwide problem. Therefore, the prevention of pollution is very important. The sewage must be treated in a harmless manner during irrigation, and the treated water must meet the water quality standards for farmland irrigation water before it can be used. Water quality is closely related to the quality of agricultural products. Irrigation water quality is not good enough to meet the production requirements of green food. In fact, China has already paid a heavy price on this issue, and it has to pay attention to it.

3. Water quality monitoring scoring standards

3.1. Evaluation criteria

The evaluation standard adopts GB5084-82 "Farmland Irrigation Water Quality Standard". This standard applies to the nationwide evaluation of farmland irrigation water that uses surface water, groundwater, treated urban sewage and industrial wastewater with similar water quality as urban sewage as water sources (Table 1).

Table 1. Farmland irrigation water quality evaluation standard mg/L

Project	Water crop	Dry crops	Project	Water crop	Dry crops
COD	≤ 20	≤ 30	lead	≤ 0.1	≤ 0.1
Total phosphorus	≤ 5	≤ 10	copper	≤ 1.0	≤ 1.0
HG	≤ 0.01	≤ 0.01	Zinc	≤ 2.0	≤ 2.0
cadmium	≤ 0.05	≤ 0.05	Fluoride	≤ 2.0 (High fluorine zone)	≤ 3.0 (general area)
Arsenic	≤ 0.05	≤ 0.05	Cyanide	≤ 0.5	≤ 0.5
Volatile Phenol	≤ 1.0	≤ 1.0			

3.2. Evaluation method

In water quality monitoring, the detection rate and over-standard rate of the arithmetic mean value of multi-point single-factor monitoring data are used as the most basic requirements and evaluation basis for monitoring (standard control method). If the monitoring results have more than 2 (including 2) individual index detected values exceeding the standard value, the calculation of the water pollution index and the water quality classification can be further carried out [5]. The pollution index method is to obtain the pollution index P_i of the single monitoring value of each index, and judge the pollution degree according to the index size. The calculation formula is

$$P_i = C_i / C_{0i} \quad (1)$$

In the formula: P_i is the pollution index of pollutant i ; C_i is the average value of the actual measured value of pollutant i ; C_{0i} is the standard value of pollutant i .

When $P_i > 1$, it means that the standard value is exceeded, and there is pollution of pollutant i ; when $P_i = 1$, that means that pollutant i in the water has reached the maximum allowable concentration of pollutant i specified by the standard, and it will cause pollutant i if it is not controlled. Pollution: When $P_i < 1$, that is, the pollutant i in the water is below the standard specified value, and it does not constitute the pollution of pollutant i . Comprehensive pollution index:

$$P = \frac{1}{n} \sum_{i=1}^n P_i = \frac{1}{n} \sum_{i=1}^n C_i / C_{0i} \quad (2)$$

When $P > 1$, there is one pollutant or multiple pollutants in the water body. The larger P is, the more serious the pollutant will be; when $P = 1$, the pollution threshold has been reached; when $P < 1$, there is no comprehensive pollution in the water body. Pollution.

4. Analysis of evaluation results

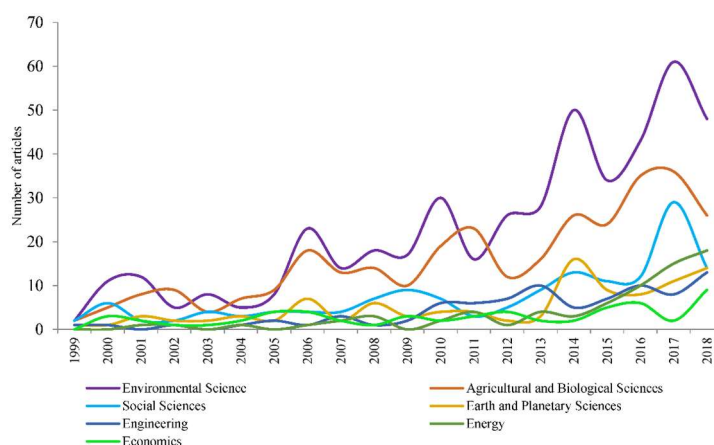
4.1. Surface water

The five-year monitoring results show that the individual pollution index and the comprehensive pollution index of the participating indicators of each river section are less than 1, and the surface water does not constitute a single pollution or a comprehensive pollution (Table 2).

Table 2. Agricultural water quality checklist

	Annual average value/(mg·L ⁻¹)	The detection rate/%	Range of annual mean Pi	P range of cross-section over the years
CODCr	11.2-69.9	77	0.065-0.94	
Kjeldahl Nitrogen	0.62-4.28	88.6	0.052-0.356	
THg	0.00003-0.00015	16.6	0.030-0.149	
TAs	0.004-0.011	17.6	0.080-0.285	
TCu	0.022-0.05	11.4	0.025-0.05	0.034-0.222
TZn	0.025-1.294	15.4	0.012-0.647	
TPb	0.005-0.022	12.9	0.050-0.217	
TCd	0.0005-0.012	4.6	0.100-0.231	
TP	0.008-0.277	72	0.002-0.055	
Salinity	275-1056	100	0.138-0.528	

The annual average value of the comprehensive pollution index is between 0.072-0.134. The water quality in the first 2 years is roughly the same, and the water quality in the next 3 years has increased slightly (Figure 1).

**Figure 1.** Variation trend of comprehensive water pollution index of underground irrigation water over the years

In general, the groundwater used for irrigation over the years met the requirements of GB5084-1992, and the water quality is good, so the groundwater used for irrigation is safe and reliable.

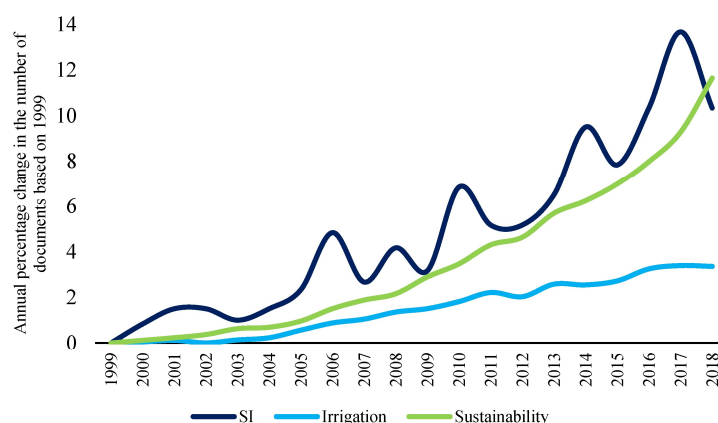
4.2. Irrigation retreat

The five-year monitoring results show that the content of some monitoring items in all the receding river sections during the five-year period is higher than that of the irrigation water. Among them, the content of the Xiyan River Lianyungang section, the Dapu River Lianyungang section, the Xiao Sui River Suining section, and the abandoned Yellow River Xuzhou section exist the two items of chemical oxygen demand and Kjeldahl nitrogen exceeded the standard. The annual average chemical oxygen demand pollution index was 5.45, and the annual average Kjeldahl nitrogen pollution index was 2.51, which constituted a single pollution [6]. The reason for exceeding the standard may be related to the use of chemical fertilizers and pesticides in the agricultural production process. The comprehensive pollution index is still less than 1, which does not constitute comprehensive pollution. Therefore, the returned water quality can still meet the requirements of agricultural irrigation water quality (Table 3).

Table 3. Statistics of monitoring and evaluation results of irrigation return water quality

	Annual average Value/(mg·L ⁻¹)	The detection Rate/%	Range of annual Mean Pi	P range of cross-section Over the years
CODCr	21.6-265.5	92.3	0.190-5.45	
Kjeldahl Nitrogen	0.74-27.01	98.2	0.061-2.251	
THg	0.00003-0.00020	12.4	0.030-0.196	
TAs	0.004-0.011	11.8	0.080-0.217	
TCu	0.025-0.047	7.7	0.025-0.047	0.039-0.71
TZn	0.025-1.09	26.6	0.013-0.545	
TPb	0.005-0.01	2.37	0.050-0.103	
TCd	0.0005-0.013	5.92	0.100-0.262	
TP	0.009-2.446	87.6	0.002-0.489	
Salinity	271-1446	100	0.136-0.724	

The annual average value of the comprehensive pollution index is between 0.127-0.249, and the annual average value is 0.188, which is 0.088 higher than the surface water used for irrigation, and has a rising trend (Figure 2).

**Figure 2.** Variation trend of comprehensive pollution index of water quality over the years of irrigation return

5. Water quality monitoring system design

According to the analysis of system functions, RWQMES requires three subsystems: remote sensing image processing, water quality prediction, and water quality evaluation. Each subsystem is composed of several items, and the function of each sub-module in the whole system can be reflected through the corresponding operation menu. The main program module of the system is mainly composed of the following modules. Figure 3 shows the system function diagram.

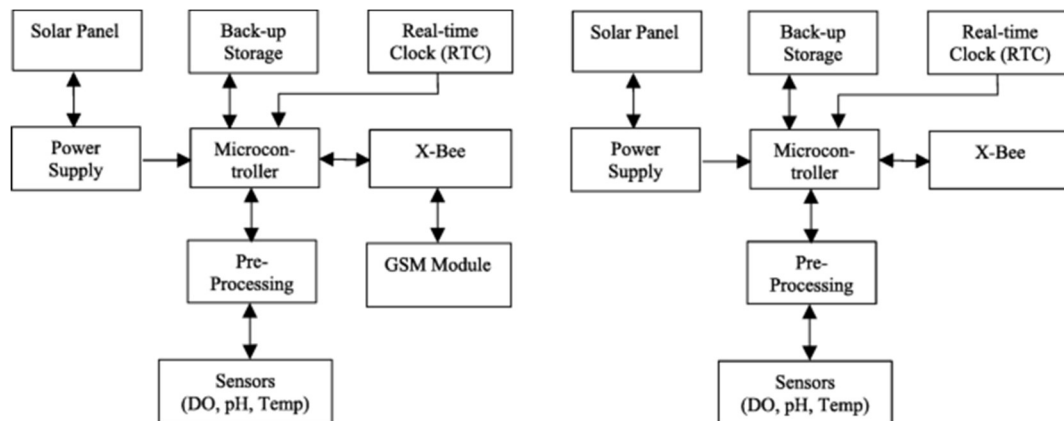


Figure 3. System function diagram

(1) File module. Including viewing images, loading images and exit functions. Viewing images can be used to view remote sensing images in jpg format and ti format.

(2) Remote sensing image processing module. Including the radiation correction and geometric correction of remote sensing images. The radiation correction includes reflectivity correction and radiation value correction. This part is used to process the remote sensing images loaded by the user in the file module. These mainly rely on the image processing technology of remote sensing images.

(3) Water quality sampling module. This module is used to provide data after water quality sampling. To sample the spectral feature data of the processed remote sensing image, the remote sensing image processing software Erdas is needed. After the software is processed, the user uploads the field data of the water quality parameters and the spectral characteristic data of the remote sensing image to the system for the use of the water quality prediction module and the water quality evaluation module.

(4) Water quality prediction module. Now includes multiple regression, support vector machine (SVM) and artificial neural network (ANN) three prediction methods. This module uses the field data of some field water quality parameters obtained by the water quality sampling module and the spectral feature data of remote sensing images, and establishes a correlation model using the method selected by the user. Then, according to the spectroscopic data provided by the user that needs to be predicted, the predicted value of the required water quality component concentration is obtained.

(5) Water quality evaluation module. Now includes two evaluation methods, concentration evaluation method and spectrum evaluation method. The concentration evaluation method is based on the prediction results of water quality parameters and the water quality standards of the National Surface Water Environmental Quality Standard (GB3838-2002) (hereinafter referred to as the national standard).

(6) View module. This module includes image display scale, tool bar, and status bar. Images can be displayed in multiple scales respectively, and the tool bar and status bar can be selected to be displayed or hidden.

6. Conclusion

China's economic growth has paid a great environmental price, and it has become the most prominent problem of economic growth. Strengthening water resources protection, ensuring the safety of water supply, forming and improving water quality monitoring work that is compatible with China's national conditions is to ensure and support the economy and society. The inevitable choice for sustainable development. In terms of agricultural water use, strengthening water quality supervision and management is also a very critical issue, which is also of positive significance for ensuring the health of agricultural ecology and the quality and safety of agricultural products, and promoting the sustainable development of agricultural production in China.

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